Predatory Morphology and Behaviour in *Branchinella occidentalis* (Dakin, 1914) (Branchiopoda: Anostraca: Thamnocephalidae)

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Branchinella occidentalis (Dakin 1914) is redescribed from material collected across the species natural distribution, with special attention to its functional morphology in relation to predatory feeding behaviour observed in the wild and in culture. We present *B. occidentalis* as a predatory anostracan with physical adaptations convergent with other large predatory anostracan taxa. Comparisons with its closest sister taxon, *B. australiensis* (Richters 1876), and with other predatory species are made and discussed. Revised and updated definitions and diagnoses for the Thamnocephalidae, *Branchinella*, and *Branchinella* sensu stricto are provided.

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Key Words: Australia, *Branchinella australiensis, Branchinecta,* fairy shrimp, predators.

INTRODUCTION

Despite being a widespread and common component of the Australian anostracan fauna (Rogers and Timms 2014), *Branchinella occidentalis* Dakin 1914 is not well characterised. Dakin (1914) described it as a variety of *Branchinella australiensis*, but Linder (1941) redescribed it as a separate species, a position maintained by Geddes (1981), Timms (2002), and Rogers (2013). However, these authors did not realise it was predatory, so that any adaptations for this mode of life went unnoticed. We present direct evidence that this species is predatory and describe some of the functional morphology related to its predatory behaviour. Given that the North American *Branchinecta gigas* Lynch 1937 and *B. raptor* Rogers et al. 2006 (Branchinectidae) display many adaptations enabling them to be successful predators (Fryer et al. 1966; White et al. 1969; Rogers et al. 2006), it is of interest to study *Branchinella occidentalis* in detail, it being a member of a different family and living on a different continent.

MATERIALS AND METHODS

Specimens were collected from the wild by dip net in inundated pools, or substrate samples were collected from dry pools and adults were cultured in the laboratory. Captured and cultured adults were preserved in 90% ethyl alcohol. After 24 hours the preservative was replaced with 70% ethyl alcohol to prevent softening or decomposition (Rogers 2002).

Laboratory cultures were run as follows: substrate containing eggs was collected from the deepest portion of pools that supported *B. occidentalis*. This substrate was placed in black plastic tubs (60cm length x 45cm width x 15cm depth, 27L volume), with each pool sample in its own tub. The tubs were filled half full with 20°C deionized tap water. The culture was gently mixed and then given rapid aeration via an air stone. The aeration was reduced to a gentle bubbling (not creating any currents or foam) after two hours. After 24 hours the culture tub was filled to capacity with 20°C deionized tap water and incubated at 20°C.

After 24 hours the cultures were treated with 5ml of powdered aquarium fish vegetable flake food and 0.5 ml of brewers' yeast suspended in 10ml of water from the culture. The cultures were fed the same again when naupliar larvae were visible in the tubs and then fed the same way every three to five days, but without the yeast. Notostracans were removed from the cultures as they were observed, as they are anostracan predators. Adult *B. occidentalis* eventually reached maturity and consumed all other nonconspecific anostracans in the culture. Other anostracans from other cultures were offered as food (*Artemia franciscana* Kellogg, 1906, *Branchinecta lindahli* Packard, 1883) and were readily taken.

Digestive tracts were dissected from fifteen specimens from five locations and the gut contents were examined.

Specimens were observed and dissected under a Wild M-5 binocular dissection microscope. Drawings were made by hand.

Material was collected and examined from various populations across Australia within the known range of the species (Fig. 1). The following abbreviations are used here: "DCR" refers to collection accession numbers in the first author's collections, "BVT" for the second. AM = Australian Museum; SAM= South Australia Museum; WAM= Western Australia Museum; CNP= Currawinya National Park.

A total of 314 *B. occidentalis* specimens were examined in this study (see Material Examined section below). In addition, the following material was examined for comparison:

Branchinella australiensis (Richters, 1876)
AUSTRALIA: NEW SOUTH WALES:
Steve's Pool, Muella Station; two males, two females; June 1999; B. V. Timms, DCR-269.
Sue's Pan, Bloodwood Station, 29° 29' 05.60"S, 144° 48' 38.00"E; 5 males, 8 females; August 2015; BVT and DCR.

Branchinecta gigas Lynch, 1937
CANADA: ALBERTA:
Chain Lakes; one male, one female; 29 May 1965; G. White, Det. DCR, DCR-223.
USA: CALIFORNIA:
Modoc County: Middle Alkali Lake, at HWY 299 causeway; four males, four females; March 1993; S. Cepello, DCR, DCR-15.
Siskiyou County:
Pool east of intersection of Highway 97 and Highway 161, on north side of Indian Tom Lake; 21 males, 33 females; 27 March 1998; DCR, R.E. Hill, DCR-127.
Pool east of intersection of Highway 97 and Highway 161, on north side of Indian Tom Lake; ten males, ten females; 18 April 2003, DCR, C.L. Rogers, S. Wile, DCR-542.

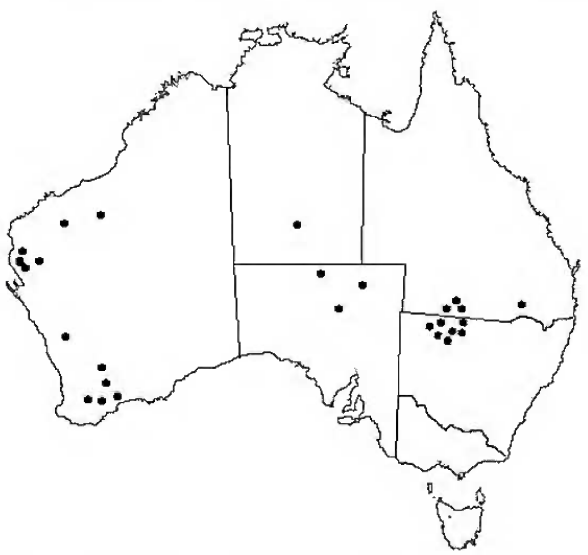

Figure 1. Distribution of *Branchinella occidentalis* based upon Geddes (1981) and Rogers and Timms (2014) and records presented here.

Branchinecta raptor Rogers et al., 2006
USA: IDAHO:
Ada County:
Orchard Training Area, Armadillo Playa; one male, one female;18 March 2004, L. Evans, D. Quinney, J. Weaver, Det. D. C. Rogers, DCR-604.
Orchard Training Area, Tadpole Lake; four males, four females; 18 March 2004; L. Evans, D. Quinney, J. Weaver, Det. D. C. Rogers, DCR-605.
Orchard Training Area, Armadillo Playa; five males, five females; 31 March 2004, L. Evans, D. Quinney, J. Weaver, Det. D. C. Rogers, DCR-606.

RESULTS

Thamnocephalidae Packard, 1883 (sensu Rogers, 2006)

Diagnosis.— (revised from Rogers, 2006) Gonopods close set, basal portions soft or rigid, with one or more longitudinal rows of spines. Eversible portion typically becoming explanate distally. Vas deferens looped dorsally. Seminal vesicles absent. Frontal appendage present or absent. Second antennae never fused, separated by labrum, with distal antennomeres curving medially or posteriorly. Antennal appendages present or absent. Second maxillae with one or two apical setae or spines. Eleven pairs of thoracopods, each bearing a single praepipodite. Adults range in length from 6 to 60mm. Two subfamilies, seven genera, ~70 species total, reported from all continents except Antarctica.

Comments.— Previous descriptions of the family have defined it in part as having maxilla II bearing a single apical seta. Below, we found that in *B. occidentalis* the maxilla II possesses two apical spines.

Branchinella Sayce, 1902

Diagnosis.— (revised from Rogers, 2006) Fully extended gonopods reaching to abdominal segment III, IV or V. Gonopods may be entirely retractile, or bearing short, rigid, tubular chitinized basal portions, which may each bear a single ventrolateral tubercle. Gonopod rigid basal portion without medial patch of spines. Gonopod distal eversible portion soft, expanded in distal third; lateral surface bearing one or more longitudinal rows of large, dense, spines; medial surface with large, small or a mixture of scattered spines sometimes in short rows. Gonopod apex truncated with a small, centered conical projection, directed distally. Brood pouch expanded proximally, narrowing abruptly to a subcylindriform structure, extending to base of abdominal segment IV, V, VI or VII. Males frontal appendage and/or antennal appendages present or absent. Male second antenna depending from head anterioventrally, slightly coalesced at base, but otherwise free. Second antenna distal antennomere arcuate or angled. Female second antennae lamellar, with truncated or slightly acute apices. Resting eggs variable. *Branchinella australiensis* is the type species of the genus by monotypy. Two subgenera: *Branchinella* sensu stricto, limited to Australia, and *Branchinellites* from Eurasia and Africa.

Branchinella (sensu stricto) Rogers, 2006

Diagnosis.— (revised from Rogers 2006) Gonopod eversible portion with posteriolateral surface bearing a single, longitudinal row of large, posteriorly directed papilliform spines. Gonopod eversible portion with distal portion with various arrangements of scattered or rows of small spines. Male frontal appendage present or absent, if present, form highly variable. Antenna like appendage absent. Resting eggs variable, usually with variously irregular polygons to moderately spinose.

Branchinella occidentalis (Dakin, 1914)
(Figure 1, 2)

Branchinella australiensis var. *occidentalis* Dakin 1914
Branchinella occidentalis (Dakin 1914) fide Linder 1941; Geddes 1981; Rogers 2006, 2013; Timms and Lindsay 2011.
Branchinecta parooensis Henry 1924
Branchinella parooensis (Henry 1924)

Diagnosis.— Length 22–50mm from frons anterior margin to telson posterior margin. Compound eye peduncle extremely short. Compound eye reduced. First antenna greatly elongated, whip like, two to six times as long as second antenna. Frons and anterior surface of antennae II broadened laterally.

Type Material.— Western Australian Museum, Perth, Australia: Syntypes, 5 km SE of Wiluna, 26° 31' 58"S, 120° 40' 1"E, 2 males, unknown collector, 1911, WAM 157, 158 . One male is dissected.

Type Locality.— Australia: Western Australia: Wiluna: Lake Violet.

Material Examined.— In addition to the syntype material, the following specimens were examined:

NEW SOUTH WALES:
Paroo, Bloodwood Station, 11.5 km NW of homestead, Sues clay pan, 29° 33' 21.7"S, 144° 50' 14.4"E; 5 males, 9 females; 1 June 1999; BVT, DCR-267.
Same site; 6 males, 9 females, 6 February, 2007; BVT; AM P99164.
Same site; 4 males, 6 females; 25 July 2015; BVT and DCR.
Paroo, Bloodwood Station, 8.9 km W of Homestead, Plover pan, 29° 31' 1.2"S, 144° 49' 39.9"E; 5 specimens; 9 June 1998; BVT; AM P99161.
Same site; 12 males, 5 females; 26 July 2015; BVT and DCR.
Paroo, Bloodwood Station, 9.8 km WSW of homestead, Melaleuca Pan, 29° 33' 02.4"S, 144° 49' 07.6"E; 8 males, 3 females; 25 July 2015; BVT and DCR.

Paroo, Bloodwood Station, 8.6 km SW of homestead, Turkey pan, 29° 33' 21.7"S, 144° 50' 14.4"E; 19 February 2010; B.V. Timms, AM P99162.
Same site; 1 June 2016; AM P99163.
Paroo, Bloodwood Station, 9.3 km NW of homestead, the freshwater lake; 11 males, 14 females; July 1997, BVT, DCR-477.
Paroo, 130 km NW of Bourke, roadside pool at Yantabulla, 29° 19' 36.7"S, 145° 00' 11.2"E; 26 males, 31 females; 6 July 2001, BVT, DCR-357.
Paroo, Goorimpa Station, a clay pan, 30° 20'S, 144° 01'E; 1 male; November 1923; M. Henry; AM P6774.

NORTHERN TERRITORY:
Alice Springs area, Illpara clay pan, Alice Springs, 23° 45' 16.5"E, 133° 47' 51.5"E; 2 specimens; 30 March 2012; G. McBurnie; AM P99151.

QUEENSLAND:
CNP, 40 km NE of Hungerford, a clay pan, 28° 44' 0.3"S, 144° 41' 27.5"E; 8 specimens; 8 June 2007; BVT; AM P.99154.
CNP, 17.3 km NNE of Hungerford, a clay pan, 28° 50' 41.0"S, 144° 26' 58.1"E; 1 September 1996, BVT; AM P99155.
CNP, 2.3 km N of Lake Karatta, a clay pan, 28° 52' 20.2"S, 144° 17' 34.7"E; 23 specimens; 2 July1993; BVT; AM P99156.
CNP, North Kaponyee Lake, 28° 49' 12.5"S, 144° 19' 21.3"E; 4 specimens; 13 July 1998; BVT; AM P99157.
CNP, South Kaponyee Lake, 28° 51' 27.5"S, 144° 20' 6.0"E; 4 specimens; 13 March 1997; BVT; AM P99158.
Paroo, Rockwell Station, 1.7 km N of Lake Bulla, a clay pan, 28° 52' 59.4"S, 144° 55' 57.4"E; 9 specimens; 9 June 2007; BVT; AM P99159.
Paroo, Rockwell Station, 5.4 km N of Lake Bulla, a clay pan, 28° 51' 4.4"S, 144° 56' 51.1"E; 53 specimens; 10 June 2007; BVT; AM P99160.

SOUTH AUSTRALIA:
Oodnadatta Track, 60 km N of Oodnadatta, Fogartys clay pan, 27° 03' 21.4"S, 135° 14' 57.2"E; 10 specimens; 11 March 2011; BVT and M. Schwentner; AM P99152.
Oodnadatta Track, 16 km N of William Ck. Pub, a clay pan, 28° 52' 3.6"S, 136° 11' 8.6"E; 13 specimens; 12 March 2011; BVT and M. Schwentner; AM P99153.
91 km S of William Ck. Pub, a clay pan, 29° 43'S, 136° 19'E, 2 specimens; 5 December 1974, SAM C6051.

WESTERN AUSTRALIA:
North of Murchison River, Gee Gie Outcrop, south end, 27° 21'S, 114° 08'E; 2 specimens; 28 November 1968; Kidner Loveland; WAM 12484.
North of Murchison River, Lake Culcurdoo, 27° 25'S, 114° 08'E; 1 specimen; 27 November 1968; Kidner Loveland; WAM 12499.
Paynes Find, 12 km S, a clay pan, 29° 19' 52.3"S, 117° 47' 23.3"E; 6 August 2004; 12 males, 10 females; BVT; DCR - 632.
Same site; 8 specimens; 21 August 2011; BVT; AM P 99149.
Ora Banda, Rowles Lagoon, 30° 25'38.5"S, 120° 51'49.7"E; 2 specimens; 10 March 2014; K Quinlan and J Jackson; WAM 59072.
Kalgoorlie, 12.7 km SSW, Lake Hannan, 30° 51' 0"S, 121° 31'58"E; 2 specimens; 17 March 1937; D. Serventy; WAM 12459.
Norseman-Lake King Road, 4.5 km N, a clay pan, 32° 39' 10.8"S, 120° 47' 8.6"E; 7 specimens; BVT; AM P99150.

Description.— Length 22 – 50mm from frons anterior margin to telson posterior margin.
Male. Head (Fig. 2A) broad, dorsoventrally flattened, frons projecting over bases of compound eyes. Dorsal organ reduced. Compound eye reduced, peduncle short, subequal in length to compound eye diameter. Naupliar eye small, deep below integument. Frontal appendage barely discernable; at most a pair of low, rounded protrusions.

Antenna I elongate, 2.0 to 6.0 times the length of antenna II. Base broad, 0.8 times width of antenna II base.

Antenna II of two articles. Proximal antennomere subcylindrical, medial surface proximal half with a low, ill defined, longitudinal ridge. Distal antennomere arcuate approximately at half its length, 1.4 times as long as proximal antennomere, tapering from a broad base to a narrow apex. Base ~0.8 times as wide as proximal antennomere distal end.

Labrum rounded transversely, projecting posteriorly over mouthparts to maxilliary gland. Posterior portion tessellated with transverse chitinized microridges. Labral projection smooth, with acute apex bending posterioventrally.

Mandible (Fig. 2C) surface with a small anterior incisor, subtended anteriolaterally by a small setal tuft. Mandible medial margin with a broadly spaced row of small denticles; grinding surface generally smooth, covered in fine denticles. Maxillary glands large, overlapping mandible base, broader distally than proximally. Maxillary gland duct opening at base of Maxilla I.

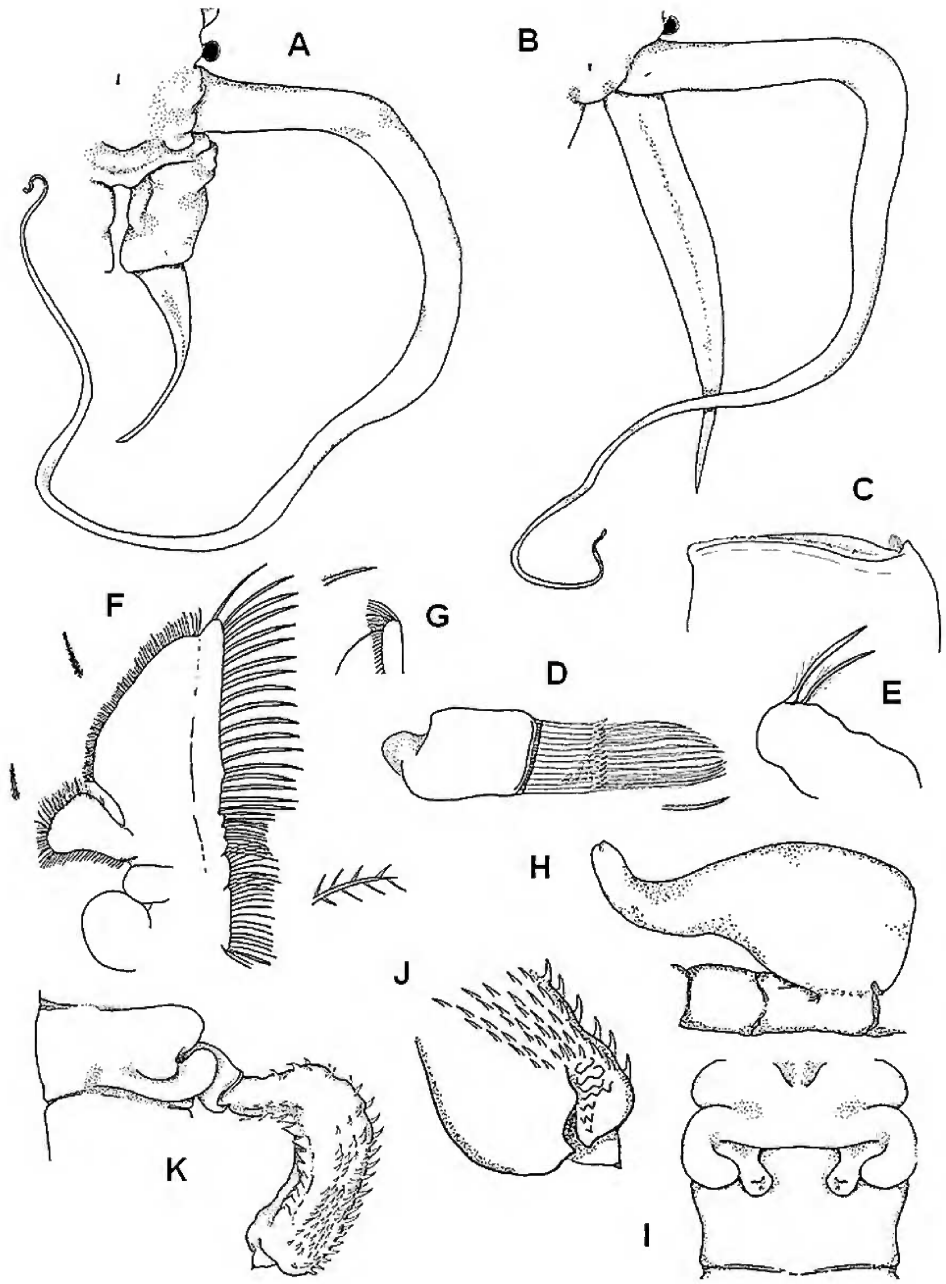

Figure 2. ***Branchinella occidentalis*****. A) Male, head, left half, anterior view; B) female, head, left half, anterior view; C) mandible, posteriomedial view; D) maxilla I, posteriomedial view; E) maxilla II, lateral view; F) thoracopod V, right side, posterior view, with inset details of seta or spine apices; G) thoracopod V, right side, distal end, posterior view, with medial margin folded back; H) brood pouch, left lateral view; I) male genital segments (abdominal segment XII + XIII) with retracted gonopods, ventral view; J) everted right gonopod apex, medial view; K) everted right gonopod, lateral view.**

Maxilla I (Fig. 2D) of two articles. Proximal article a short, subcylindrical peduncle. Distal article broadly rectangular, distal margin fringed with a close set row of stout setae. Setae composed of two portions: proximal portion stout, rigid, and with a distal spine. Posterior most setae, except ultimate and penultimate, bearing one to four subdistal rounded spines. Setal distal portions, soft, flexible, and pectinate. Posterior most setae longer than anterior most setae.

Maxilla II (Fig. 2E) lobiform, with two distal spines, each plumose proximally.

Thoracic segments smooth, unadorned. Feeding groove absent, ventral surface flat, broad.

Thoracopods serially homologous and elongated. Thoracopod V (Fig. 2F) with endites lamellar. Endite I+II oblong, medial edge straight, margined with elongate setae bearing numerous spinulae, spinulae separated by at least their length. Seta length subequal to endite I+II breadth.

Endite III rounded, ~0.5 times the breadth of endite I+II, margined with elongate setae bearing numerous spinulae, each separated by a distance at least equal to their length. Seta length subequal to endite I+II breadth.

Endites IV, V, and VI rounded, each ~0.5 times the width of endite III, margined with elongate setae bearing numerous spinulae, each separated by a distance at least equal to their length. Seta length subequal to endite I+II breadth.

Endopod medial margin plus all endites as one body articulate, bending posteriorly, and capable of lying flat against limb posterior surface (Fig. 2G).

Endopod broadly triangular, distomedial corner projecting ventrally. Endopod mesal edge and projecting distomedial corner margined with stout, aciculate, bipectinate spines. Spines vary in length among individuals from one half to subequal the breadth of the endopod. Endopod ventrolateral edge margined with short setae, covered in fine setulae. Each seta ~0.2 times the length of the endopod medial spines.

Exopod, lamellar, distally explanate ovate, with rounded corners, generally margined with short setae, covered in fine setulae. Each seta ~0.2 times the length of the endopod medial spines. Ventral margin with some setae set back from margin on both anterior and posterior surfaces.

Epipodite a short, rounded lobe, inerm. Praeepipodite broadly circular, inerm.

First genital segment (thoracic segment XII) (Fig. 2I, K) tumid, with several ventral folds, overlapping gonopod bases anteriorly, and laying over base of second genital segment (thoracic segment XIII) on lateral sides of gonopods.

Gonopod basal portions (Fig. I) close set to medial line, subcylindrical, smooth, arcing medioventrally. Gonopod distal portions (Fig. 2K) arcing posteriomedially, extending posteriorly to abdominal segment II or III, with apex explanate and truncated. Anterior, lateral and medial surfaces with confused longitudinal rows or recurved spines, becoming more confused distally. Distal most spines becoming nearly straight, subcylindrical, and one fourth shorter than more anterior spines. Gonopod posteriolateral surface with a longitudinal row of broad, triangular, lamellar, papillae, each tipped with a short, rounded chitinized spine. Gonopod apex (Fig. 2J) with a conical papilla, tipped with a small rounded spine. Gonopore opening in a subapical narrow slit, positioned medially and opening subapically at the base of the apical, conical papilla.

Abdominal segments and telson subcylindrical, smooth, unadorned.

Cercopods long tapering cones, apically subacute, subequal in length to the last two abdominal segments plus telson. Each cercopod with medial and lateral margins fringed with long, plumose setae.

Female. Head (Fig. 2B), eye and antenna I as in male. Antenna I length ~2.3 times antenna II length, with basal width equal to antenna II basal width. Antenna II broadly lamellar, tapering to an acute apex. Mouth parts, thorax and thoracopods as in male.

First genital segment (thoracic segment XII) smooth. Brood pouch (Fig. 2H) subconical, tapering posteriodistally to simple gonopore, directed posterioventrally. Gonopore posterior lip projecting distally, subacute.

Abdomen, telson and cercopods as in male.

Egg.— (After Timms & Lindsay 2011) Diameter ~500 µm. Average size 492.2 µm. Surface with numerous polygons. Polygonal depressions fewer and shallower in western populations than eastern. Polygonal depressions with steep walled ridges crested with a fringe of short spines. Ridge walls with scattered pores. Polygonal depressions with floors flat and dimpled or markedly concave.

Distribution and Habitat.— *Branchinella occidentalis* is widespread across arid Australia in the Western and Eastern Australian Anostracan Bioregions (Fig. 1)(Rogers & Timms 2014). Habitat is general deep and turbid, with some level of substrate salinity and carbonate present and with acid sulfates present or not (Rogers & Timms 2014). Localities for this species are in calcarosol, dermosol, hydrosol, kurosol, sodosol, tenosol, and vertisol soils (Rogers & Timms 2014).

Branchinella occidentalis is known from 42 locations (Rogers & Timms 2014) and is found co-occurring with *Branchinella lyrifera* Linder 1941 (21.4% of records), *B. affinis* Linder 1941(11.9%), and *B. australiensis* (9.5%). It also co-occurs with *B. probiscida* Henry 1924, *B. pinnata* Geddes 1981, *B. halsei* Timms 2002, *B. budjiti* Timms 2001, *B. frondosa* Henry 1924, and *Streptocephalus archeri* (Sars 1896), (all <7%); however the one, two, or three records for each of these species were always occurrences with one or more of the primary three co-occurring species. *Branchinella occidentalis* was found on five occasions to be the only active resident of the pool (11.9%).

Behaviour.— Nine specimens of large adult, field collected, preserved *B. occidentalis* material from various locations were found with *B. lyrifera* or *B. affinis* protruding at various distances from the mandibles. In culture, large adult *B. occidentalis* were observed to consume live *B. lyrifera*, *B. affinis*, and *B. frondosa* as well as cladocerans that hatched in the same culture, as were *Artemia* sp. and *Branchinecta* sp. that were offered to them. Dead or moribund specimens were ignored.

Predatory behaviour was only ever observed in animals greater than 5cm in length, and only towards anostracans that were 2cm in length or smaller.

Capture was observed several times: the larger *B. occidentalis* detected the smaller anostracan between it and the culture tub wall or the substrate. The *B. occidentalis* rolled over with its venter to the substrate and pressed down over the prey item, occasionally arcing its body. Eventually, the *B. occidentalis* came away from the substrate with the prey item in its jaws.

Prey always appeared to be identified by tactile and not visual detection. Prey was always consumed abdomen first. Specific manipulation of the prey was not clearly observed. However, the limbs were directly involved in pinning the prey, orienting it with the abdomen towards the mandibles, and moving it towards the mandibles.

Only one prey item at a time was ever observed in the jaws of any one *B. occidentalis*. Prey was never observed to be carried for later consumption as in *Branchinecta raptor* (Rogers et al. 2006). When prey items were not available, filamentous green algae and periphyton were consumed.

Gut contents.— Only *B. occidentalis* specimens greater than 5cm in body length had macrometazoans in the gut. All specimens examined had micrometazoans, algae, diatoms, detritus, chironomid midge larvae, and clay particles. Both male and female *B. occidentalis* had the remains of anostracans in the gut. One specimen from Yantabulla also had cladocerans (unidentifiable to family) present in the gut.

DISCUSSION

Branchinella occidentalis is presented here as a large predatory anostracan. Direct observations demonstrate that it is predatory on smaller anostracans and occasionally cladocerans as a large adult, but that it still will filter feed and scrape periphyton.

The modified thoracopods of *B. occidentalis* provide a limited degree of dexterity for the manipulation of prey, but not anywhere near the dexterity level observed in *B. raptor* or *B. gigas* (Rogers et al. 2006). The various other hunting methods and postures observed in the predatory *Branchinecta* species (White et al. 1969; Rogers et al. 2006) were never observed in *B. occidentalis*, and it may be that this species is less specialised than the other species.

Dakin (1914) figured the fourth limb (with no real description of it), but the limb appears to be from a juvenile individual. The differences between Dakin's (1914) limb and limbs in our adult material suggest that a serial study of the development of the limbs and mouthparts may demonstrate that this species changes feeding modes over time, as was reported for *B. gigas* and *B. ferox* (Milne-Edwards 1840) (sensu Petkovski,1991) (Daborn 1975). Dakin's (1914) only real comment on the limbs was their superficial similarity with those of *B. australiensis*.

Geddes (1981) provided a very brief redescription of *B. occidentalis*, but did not note the folding adaptation of the limb medial margin. Geddes (1981) did comment on the modified head and eyes and strangely stated that the modifications were analogous to the condition in *Dendrocephalus* (no citation provided): however, no such modifications of the head or eyes exist in that genus.

Geddes (1981) depicts the mouthparts for *B. australiensis*. Both in Geddes study and in our own we found that labrum, maxilla I and II, are nearly identical to those in *B. occidentalis*; however in *B. australiensis* the maxilla II spines are widely separated.

The morphology and behaviour of *B. occidentalis* is convergent with that of the largest two species of *Branchinecta*, both of which are known predators (Fryer 1966; Rogers et al. 2006). Specifically, the abnormally large size, reduced eyes, elongated first and/or second antennae, and modified mouthparts are convergent with the two *Branchinecta* species.

Granted, not all these characters are modified in the same manner, but they are modified to support a predatory lifestyle. The limb modifications are very different; in *B. raptor* and *B. gigas* endites I and II are not fused (as in all other anostracans), and the endites and the endopod medial margin are not articulated (Rogers et al. 2006). Rather the endites in these two species are modified for gripping and the endopod for grappling (Rogers et al. 2006).

Our study demonstrates that a predatory lifestyle in the Anostraca has evolved more than once and in more than one family. It remains to be seen if *B. australiensis* is also actively predatory.

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